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James R. Markusen

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POSSIBLE CASES

James R. Markusen

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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POSSIBLE CASES

James R. Markusen

Department of Economics

University of Western Ontario

Canada

and

Department of Economics

University of New South Wales

Australia

Department of Economics Library

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University of Western Ontario

ABSTRACT

Several models are presented in which factor mobility leads to an increase in the volume of world trade. Most of the models share the common characteristic that the basis for trade is something other than differences in relative factor endowments. These alternate bases for trade include returns to scale, imperfect competition, production and factor taxes, and differences in production technology. Taken together, the models suggest a more general idea: the widely held notion that trade in goods and factors are substitutes is in fact a rather special result which is a general characteristic only of factor proportions models.

First Draft, December, 1980.

I. INTRODUCTION

It is probably fair to say that international trade theory has devoted far more attention to commodity trade than to factor movements. Perhaps this largely reflects the relative importance of the two in the volume of international economic activity. Yet perhaps it also reflects a deeply ingrained notion that trade in commodities and factor movements are substitutes. By this I mean the concept that trade is caused by unequal factor endowments across countries and thus the equalization of endowments through factor mobility will lead to the elimination of commodity trade. Gains from trade can be realized either through the movement of goods or factors, the two being equivalent.

The first formal exposition of this idea is credited to Mundell (1957), who presented a two-good two-factor treatment of the problem. Mundell noted that in the presence of tariffs, the relatively low priced factor in each country will be that country's abundant factor. Factor mobility in response to these international factor price differences would thus lead to the elimination of trade via the elimination of the factor proportions basis for trade. More importantly, perfect factor mobility was shown to produce an international equilibrium in which factor prices and commodity prices were identical to those characterizing a free-trade equilibrium in which factors were immobile. It is in this sense that factor movements and commodity trade are thought to be substitutes, perhaps giving us an analytical basis for focusing on one type of activity (goods trade) somewhat to the exclusion of the other (factor trade).

All of this is not to say that factor movements have no interesting characteristics. Recent papers by Bhagwati (1963), Brecher and Alejandro (1977), and Markusen and Melvin (1979), for example, note that tariff-generated factor movements may (locally) reduce the real income of one country or even the real income of the world as a whole. Yet even these results rely on goods and factor trade being substitutes. As is clear from

Jones (1967), tariffs imply that any reduction in imports at a constant terms of trade reduces national income (the "volume-of-trade effect"). This follows from the fact that the benefits derived from an additional unit of the import good (given by the domestic price ratio) exceed the cost of obtaining an additional unit (given by the world price ratio) due to the tariff. If tariff-generated factor movements have the Mundell effect of reducing trade, they thereby reduce income in the absence of a favorable terms-of-trade change. It is only after trade has been eliminated that further factor movements are certain to increase income (Brecher and Alejandro (1977) and Markusen and Melvin (1979)).

The purpose of this paper is to examine a number of situations in which factor movements and trade in commodities are compliments; that is, factor movements between two economies lead to an increase in the volume of commodity trade. In several models, I will point out cases not previously analyzed while in others, I will provide a summary of cases contained either implicitly or explicitly in the works of earlier authors.

The models developed below are all two-good, two-country models in which no more than two factors are used in the production of any one good. Complimentarily between trade in goods and factors in the models has its roots in four types of underlying economic structures. The first occurs when trade equalizes commodity prices and marginal rates of transformation (MRT) in production between countries, but does not equalize factor prices. Situations of this type are well known and indeed many textbooks are quick to point out the very limited circumstances in which factor-price equalization follows from commodity price equalization. Specifically, we will be interested in situations in which commodity price equalization implies a relatively high price for the factor used intensively in each country's export good. In these cases, factor mobility makes each country even better endowed with the factor used intensively in the production of its export good and thus leads to an increase in the volume of trade.

Three cases falling into this category are analyzed. In the first, countries are assumed to have identical factor endowments, but differing production technology. As is well known, factor price equalization does not usually follow from this type of (Ricardian) trade model (see for example, Caves and Jones (1973)). Second, a model is presented in which there are external economies of scale in the production of one good. Countries are assumed to have equal relative factor endowments, but may differ in size. Factor price equalization is generally not a property of equilibrium as shown by Jones (1968), Melvin (1969), Kemp (1969), and Markusen and Melvin (1981). Third, a sector-specific-factors model with endowments unequal between countries is presented (Jones (1971), Caves (1971), Mussa (1974), Mayer (1974) and Neary (1978)). As shown by Jones, factor prices depend on factor endowments as well as on commodity prices in such a model. The contribution here is to note that while unlimited factor mobility will produce the Mundell solution, mobility of only a subset of factors may lead to an increase in commodity trade.

The second category is composed of cases in which producer prices and thus MRT are not equalized by trade. Many such cases have been analyzed in the theory of distortions (Bhagwati and Ramaswami (1963), Bhagwati (1971)) and only one will be presented here. This involves the model used by Melvin (1970) in which countries are identical in all respects except that one country has a production tax. The country with the tax will import the taxed commodity, and each country will have a relatively high price for the factor used intensively in the production of its export good.

The third category involves cases in which producer prices are equalized by trade, but MRT are not. Three situations are considered. First, it is assumed that the production of one good is monopolized in one or both of the countries, and that countries have identical relative factor endowments (Melvin and Warne (1973), Markusen (1981)). If production is only

monopolized in one country, the outcome is similar to the production tax case. If production is monopolized in both countries but the countries differ in size, then a Cournot-Nash equilibrium will lead to differing relative commodity outputs and unequal factor prices (Markusen (1981)).

The other two cases falling into this third category involve factor market distortions. A sector-specific-factors model is developed in which there are differing factor taxes across countries. Again, I think that it is reasonably well known that factor price equalization will not be a characteristic of such a model (Magee (1971), (1973), Herberg and Kemp (1971)). I will once again simply show that the direction of the inequality can be such that the relatively highly priced factor in each country is the factor used intensively in the export industry. The other case considered involves the closely related issue of factor-market monopsony (Feenstra (1980), McCulloch and Yellen (1980), Markusen and Robson (1980)). While these models can become rather complex, a simple specific-factors case is constructed in order to reduce the problem to a situation analytically similar to the factor-tax case.

The final category involves situations in which the trading equilibrium is characterized by specialization in production. In the familiar Heckscher-Ohlin model this produces unequal factor prices but the inequality is characterized by a relatively low price for the factor used intensively in the production of the export good in each country. Factor mobility thus continues to generate the Mundell effect. In the model presented below (due to Melvin (1969)), on the other hand, countries are assumed to be identical in all respects and production is assumed to be characterized by increasing returns to scale (the external economies type) such that the production set is non-convex. It is easily shown that the specialized equilibrium involves an inequality in factor prices opposite to that characterizing the usual specialized Heckscher-Ohlin equilibrium.

With the exception of the sector-specific-factors case, all of these models share the property that the basis for trade is something other than differences in factor proportions. Bases examined include returns to scale, imperfect competition, production and factor taxes, and differences in production technology. At some risk of overstatement, let me therefore suggest that the Mundell result (the substitutability of trade in goods and factors) is a very special property which is generally valid only for the factor proportions basis for trade. Alternate bases for are often characterized by a complementarity between trade in goods and trade in factors.

II. DIFFERENCES IN PRODUCTION TECHNOLOGY

In this section, we will consider differences in production technology as a basis for trade and examine a set of circumstances under which this implies a complementarity between goods and factor trade. It is assumed that two goods (X and Y) are produced from two factors (L and K) in each of two countries (h and f) which have identical factor endowments. In this section and in all subsequent sections, it is assumed that total factor supplies are fixed. Denoting countries with superscripts, the production sectors are summarized as follows:

$$\begin{aligned} (1) \quad Y^i &= G(L_y^i, K_y^i) & \bar{L} &= L_x^i + L_y^i \\ X^i &= \alpha^i F(L_x^i, K_x^i) & \bar{K} &= K_x^i + K_y^i \end{aligned} \quad i = f, h.$$

G, F, \bar{L} and \bar{K} are assumed to be identical across countries. Industries are competitive, and F and G are characterized by constant return to scale. Countries differ only in the technical efficiency parameter α^i attached to the production function for X. We will arbitrarily assume $\alpha^h > \alpha^f$, indicating superior technology in country h. Throughout the paper, it is assumed that demand in the two countries can be represented by a set of identical, homothetic, community indifference curves.

Figure 1 shows the model in output space while Figure 2 depicts input space. $O_x \bar{L} O_y \bar{K}$ in Figure 2 is a standard Edgeworth box and $O_x F A H O_y$ traces out the contract curve (the smaller factor box in Figure 2 is not relevant to this section). It is important to note that the contract curve is identical in countries h and f. Country h has a Hicks-neutral technical advantage over f which renumbers the X isoquants in h relative to those of country f. However, the marginal rate of substitution along an X isoquant for a given input bundle takes on the same value (F_L/F_K) in each country. Thus point F in Figure 2 is an efficient production point for both countries and is characterized by the same MRS and factor price ratio for both countries. As reflected in Figure 2, X is arbitrarily assumed to be the labour intensive good.

\bar{YX}^f and \bar{YX}^h in Figure 1 denote the efficient production frontiers of countries f and h respectively. Let point F in Figure 1 denote the output bundle for country f corresponding to the efficient input bundle F in Figure 2. If this is the case, then point B in Figure 1 is the output allocation for country h that corresponds to the input allocation F in Figure 2. With both countries at the input allocation F in Figure 2, country h produces the same Y but more X relative to country f.

Now assume that F in Figure 1 is the free-trade production bundle of country f. The slope of \bar{YX}^f gives the free trade price ratio. If this is the case, then the free-trade production bundle for country h must be "downhill" of B at a point like H in Figure 1. It is easy to show that at B, the MRT in production in h is less than the MRT in f. Beginning at B, competitive producers in h would expand X production until an equality between the MRT and the world price ratio was reached at H.

Differentiating X and Y, we have

$$(2) \quad dY^1 = G_L dL_y^1 + G_K dK_y^1 = -G_L dL_x^1 - G_K dK_x^1$$

$$dX^1 = \alpha^1 F_L dL_x^1 + \alpha^1 F_K dK_x^1$$

FIGURE 1

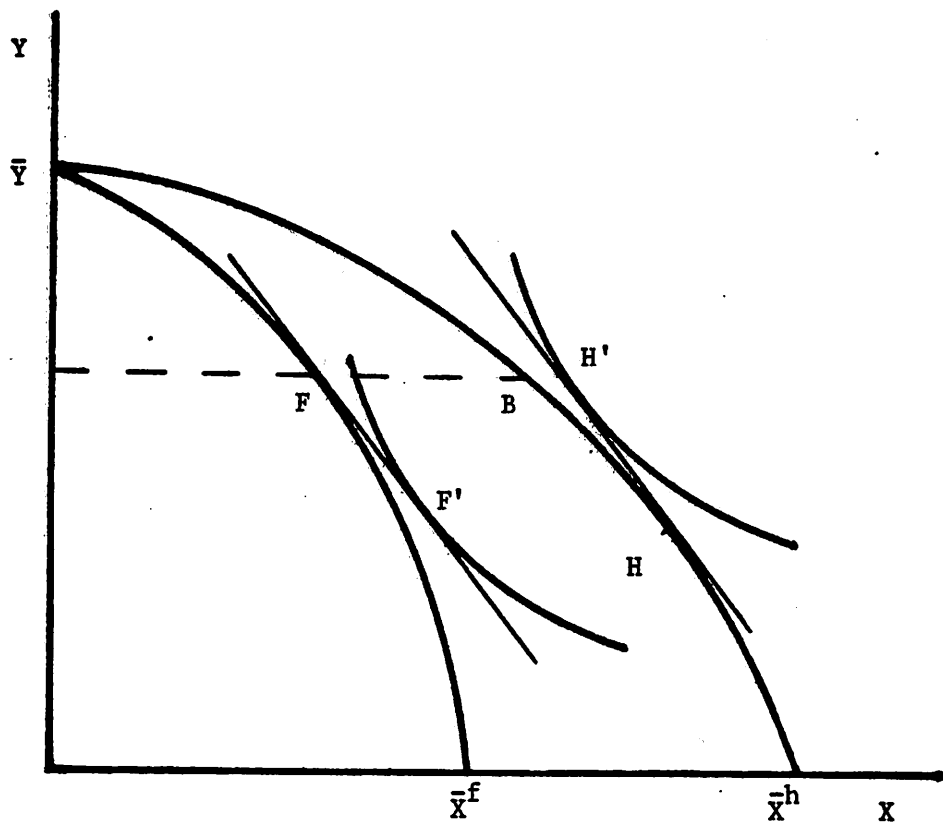
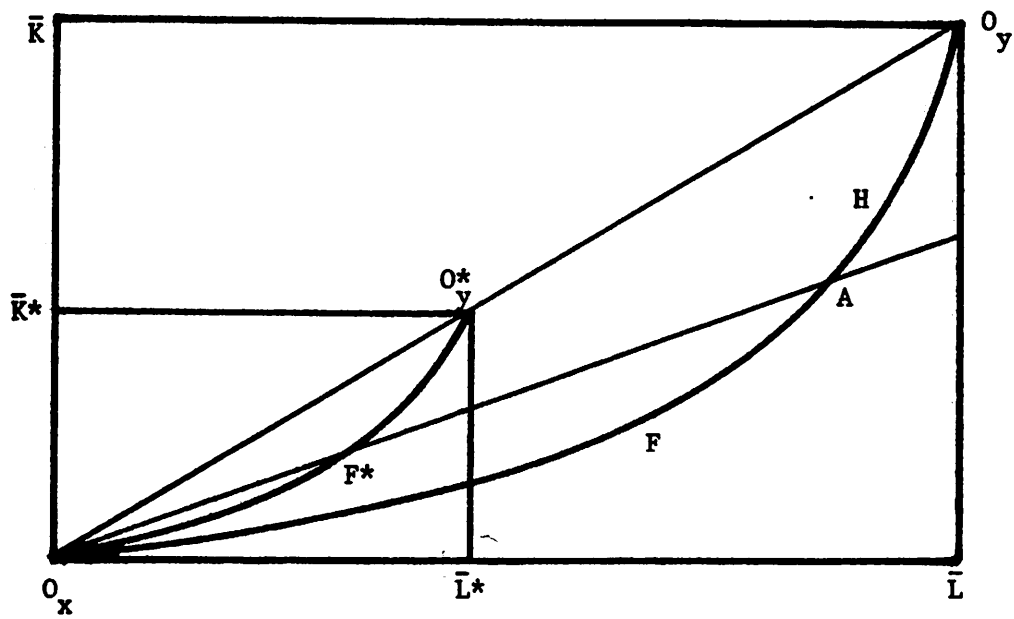


FIGURE 2



Dividing, we have the MRT for country 1.

$$(3) \quad -\frac{dY^1}{dX^1} = \frac{G_\ell + G_k (dL_x^1/dK_x^1)}{\alpha^1 (F_\ell + F_k (dL_x^1/dK_x^1))} = (MRT)^1$$

At factor allocation F in Figure 2, F_1 , G_1 , and dL_x^1/dK_x^1 (the slope of the contract curve) are identical for countries h and f. Since $\alpha^h > \alpha^f$ by assumption, the MRT at B in Figure 1 is thus less than the MRT at F in the same diagram.

If points H and F are thus the free-trade equilibrium production points for h and f, two things can be established directly. First, h must export X and f must export Y. Points H' and F' in Figure 1 illustrate free-trade consumption bundles for the two countries. Second, the real price of L will be higher in h and the real price of K will be higher in f. Let H in Figure 2 be the input bundle for h corresponding to the output bundle H in Figure 1. Let p^* denote the world price of X in terms of Y and let w^1 and r^1 denote the prices of L^1 and K^1 in terms of Y. Competitive equilibrium implies that the price of each factor equals the value of the factor's marginal product.

$$(4) \quad w^1 = p^* \alpha^1 F_\ell = G_\ell, \quad r^1 = p^* \alpha^1 F_k = G_k$$

The differences in equilibrium factor prices follow directly from the equations $w^1 = G_\ell$ and $r^1 = G_k$. With constant returns in Y, it is well known that marginal products depend only on the ratio of inputs. Since (K_y/L_y) at H in Figure 2 exceeds (K_y/L_y) at F in that diagram, it follows that G_ℓ at H exceeds G_ℓ at F and vice versa for G_k . Thus $w^h > w^f$ in terms of Y but also in terms of X since commodity prices are the same in the two countries. Similarly, $r^h < r^f$.

If we now allow factors to move between countries, L will migrate to country h and/or K will migrate to country f. Each country will be receiving more of the factor used intensively in the production of its export good. This adds a Heckscher-Ohlin basis for trade which acts to reinforce the

FIGURE 3

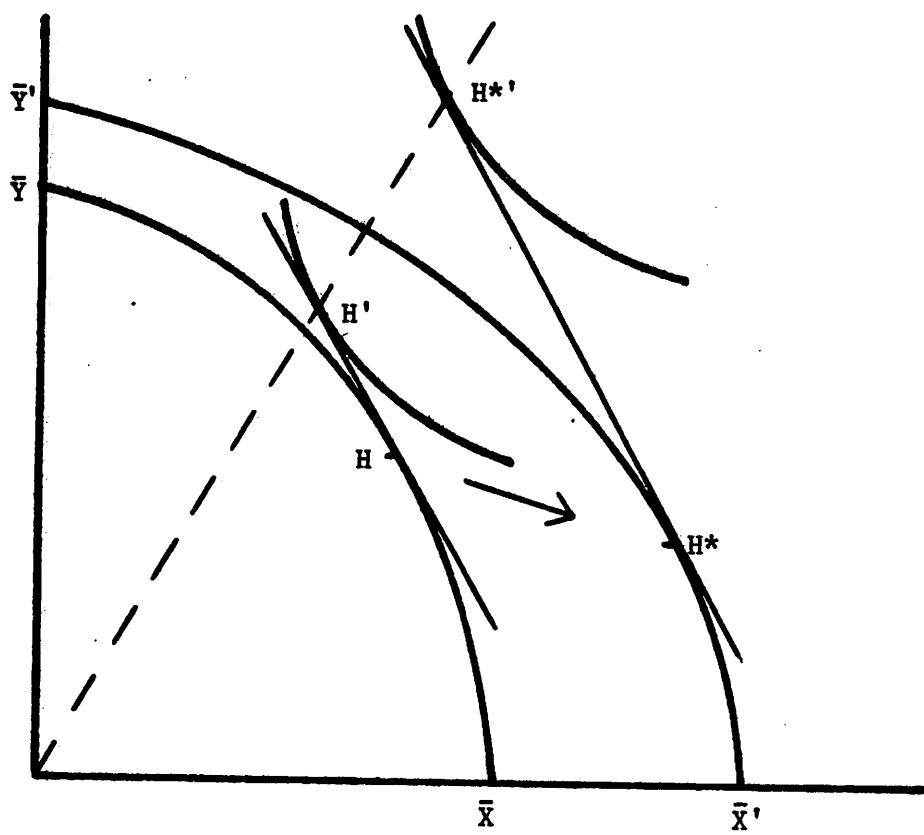
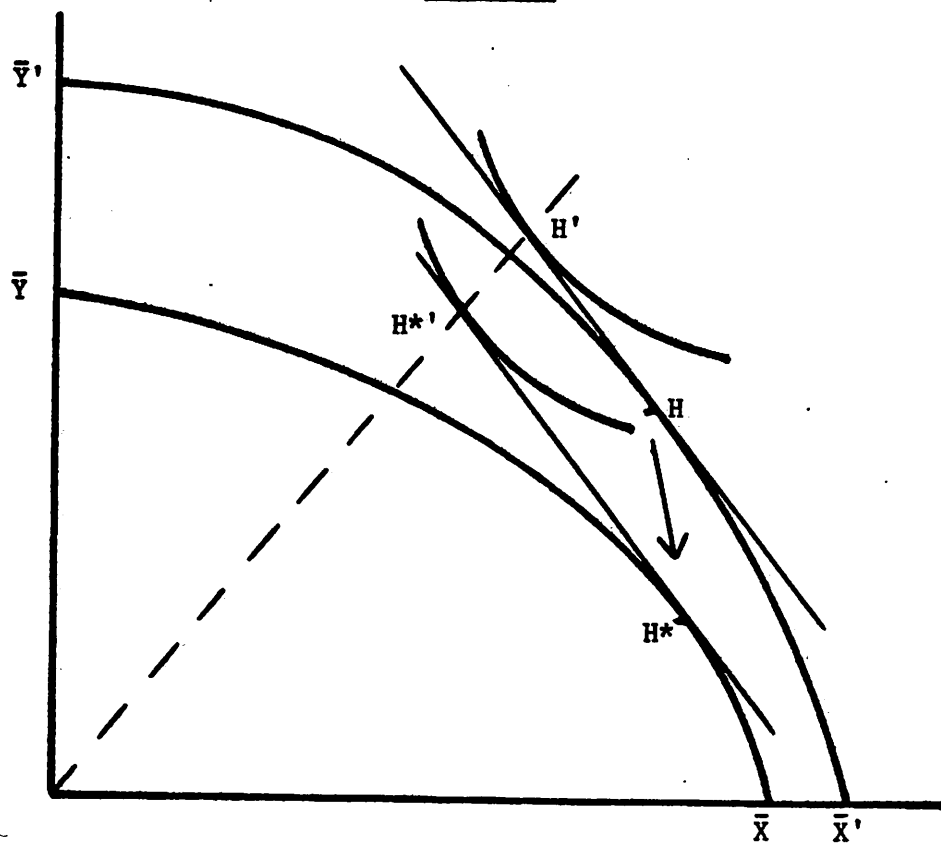


FIGURE 4



direction of trade produced by the differences in production technology.

The fact that this must lead to an increase in the volume of trade follows from the Rybczynski theorem and from the assumption of homothetic demand. Holding commodity prices constant, either an increase in \bar{L}^h or a decrease in \bar{K}^h must move the production point H in Figure 1 to the south-east.

Figure 3 shows an increase in \bar{L}^h moving production from H to H* at constant terms of trade. Figure 4 shows a movement of production from H to H* in response to a decrease in \bar{K}^h . Homotheticity in demand implies an outward shift in consumption from H' to H*' in Figure 3 and a corresponding inward shift in consumption from H' to H*' in Figure 4. If \bar{L} has increased (Figure 3), desired exports of X will increase since production of X has expanded relatively more than the demand for X. If instead \bar{K} has decreased (Figure 4), desired exports will also increase since consumption of X decreases while production of X increases. Thus in either case, country h's offer curve will shift out in excess demand space. In both Figures 3 and 4, the trade vector H*H*' exceeds the trade vector HH'. Given the usual assumptions about offer curves (elasticities greater than one is sufficient), factor mobility thus leads to an increase in the volume of trade¹.

Factor movements can only come to an end after h has specialized in X and/or f has specialized in Y. If I can avoid using another diagram, simply picture two unit-value isoquants in L and K space as per the usual analysis with X labour intensive. At the same value of p^* , the unit-value isoquant for X^h will be closer to the origin than the similar isoquant for X^f . The unit-value isoquants for Y^h and Y^f will be identical. The factor-price ratio (w/r) necessary for diversified production must therefore be higher in h than in f (factor intensity reversals ruled out). Factor movements will continue in the direction indicated until h specializes in

X and $(w/r)^h$ begins to fall relative to $(w/r)^f$ and/or until f specializes in Y.

III. PRODUCTION TAXES

Complimentarity of goods and factor trade as a result of production taxes was treated briefly in a paper by Melvin (1970). Since factor mobility was only a side issue addressed by Melvin, I would like to expand upon his idea here. Assume a two-good, two-factor, Heckscher-Ohlin production model with identical production functions and factor endowments across countries. Production is competitive and characterized by constant returns. The identical product transformation curves for countries h and f are given by \bar{YX} in Figure 5. The larger factor box in Figure 2 continues to represent the problem in input space. Assume finally that country f institutes a tax, T, on the production of X. Denoting the producer price of X in terms of Y as p^i in country i, and the consumer price of X in terms of Y as q^i , price relationships are given as follows:

$$(5) \quad p^f(1+T) = q^f = p^*, \quad p^h = q^h = p^*, \quad p^h > p^f.$$

Given our demand assumptions and given $p^i = (MRT)^i$, the free-trade equilibrium must be as shown in Figure 5. Countries h and f produce at H and F and consume at H' and F' respectively. Identical transformation curves together with (5) imply that h produces more X and less Y relative to F. Combined with homothetic demand and equal consumer prices, this in turn implies that country h exports X and country F exports Y. Production taxes can in this manner form a basis for trade. It also follows from the Stolper-Samuelson theorem that the real price of the factor used in the production of X is higher in h than in f and vice versa for the other factor. Since X is labour intensive by assumption (Figure 2), $w^h > w^f$ and $r^h < r^f$. Each country has the higher real price for the factor used intensively in the production of its export good.

FIGURE 5

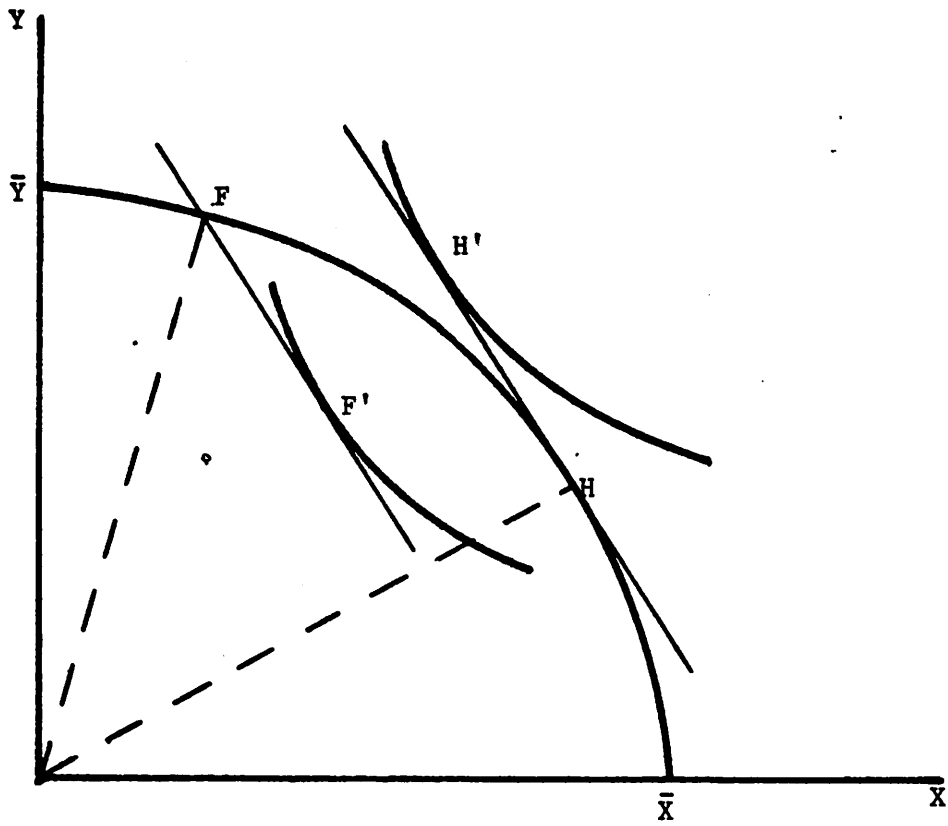
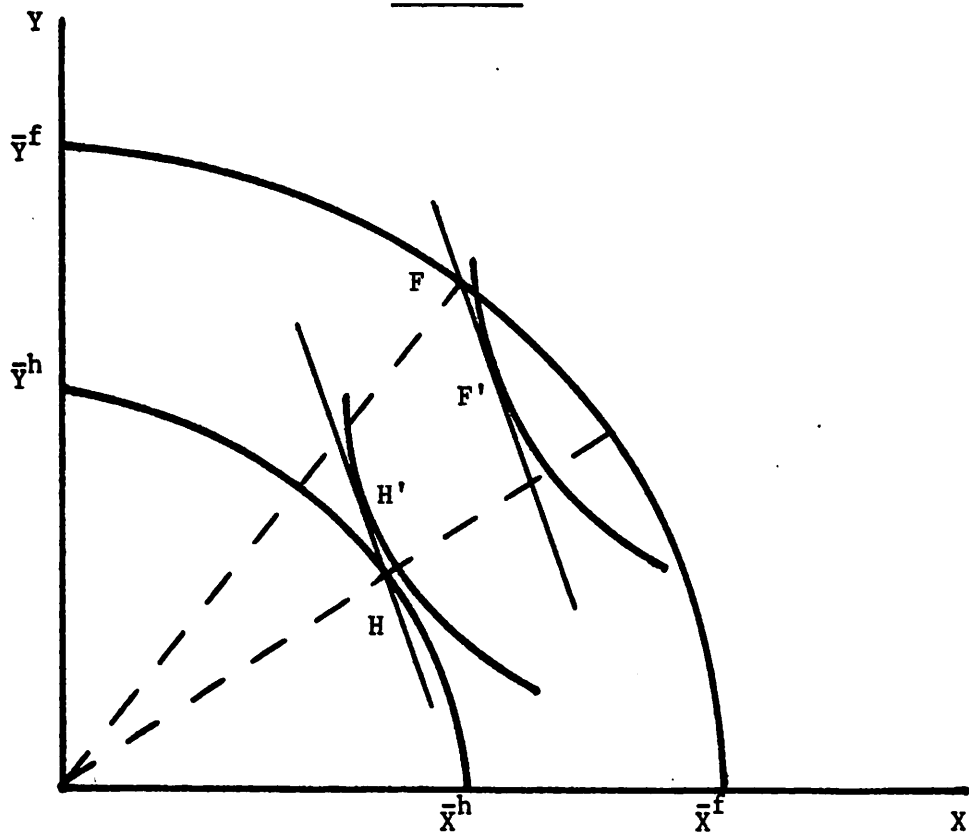


FIGURE 6



If factors are permitted to move, L will flow into h and/or K will flow into f. The Rybczynski analysis of Figures 3 and 4 remains essentially valid given that the "wedge" between p^* and $(MRT)^f$ is constant. Since the Rybczynski theorem is based on a constant MRT, the output changes described in Figures 3 and 4 continue to be valid except that the world price ratio cuts the transformation surface in country f at a constant angle². Each country will wish to trade more at any world price ratio and thus the volume of trade will increase subject to the caveat on offer curves mentioned in the previous section.

Once again, factor prices will not equalize until after h specializes in X and/or f specializes in Y. When a country is diversified, it is well-known that factor prices depend only on producer prices in this type of model. This results in the factor price equalization theorem when producer prices are equalized by trade. In the present situation, the relative producer price of X is always higher in h and thus the real price of L (K) is always higher in h (f) provided that both countries are diversified. Factor prices only begin to converge when h specializes in X and/or f specializes in Y.

IV MONOPOLY

One of the first formal treatments of monopoly as a basis for trade is that of Melvin and Warne (1973). Their analysis was extended to explicitly treat oligopolistic interdependence by Markusen (1981). Neither paper is however concerned with factor mobility and what I shall do here is show how their models can imply a complementarity between goods and factor trade.

Two versions of the problem are considered. In the first, the X sector in country f is monopolized while all other sectors in the two countries are competitive. In the second, the X sector is monopolized in both countries and the two duopolists behave in a Cournot-Nash fashion when trade takes

place. The two-good, two-factor, Heckscher-Ohlin production model with constant returns to scale is employed once again. In the first version, the two countries have identical factor endowments while in the second, they have identical relative factor endowments (the countries can differ in size). Monopolists are assumed to behave as price-takers in competitive factor markets, implying that production takes place on the efficient production frontiers.

Suppose then that X is monopolized in country f. The first-order conditions for a trading equilibrium follow from Melvin and Warne.

$$(6) \quad q^f(1-1/\eta_x) = p^*(1-1/\eta_x) = (MRT)^f$$

$$q^h = p^* = (MRT)^h$$

where η_x denotes the world elasticity of demand for X. It is assumed that $\eta_x > 1$ over the relevant range. It is also assumed that η_x depends only on p^* which in turn depends only on the world output ratio $(Y^h + Y^f)/(X^h + X^f)$. Melvin and Warne and Markusen show that all of these assumptions can be satisfied by a C.E.S. utility function with an elasticity of substitution greater than one.

Graphically, the free-trade equilibrium looks the same as the production tax equilibrium shown in Figure 5. The equilibrium world price ratio is tangent to the production frontier for country h but cuts the frontier for country f. Given the Heckscher-Ohlin production structure and competitive factor markets, the real price of labour is higher in h and the real price of capital is higher in f assuming again that X is labour intensive. The demand assumptions together with equalized consumer prices imply that country h must export X.

Factor mobility will again result in an inflow of the factor used intensively in the production of each country's export good. Again, factor price equalization will not occur as long as both countries are diversified, so a specialized equilibrium will be the outcome if factors are perfectly

mobile (h specialized in X and/or f in Y). This has an interesting sidelight which I'm not sure has been pointed out before: in the open economy, factor mobility can effectively limit product-market monopoly power. Exercised market power involves an income transfer from factor owners to the monopolist thus suggesting an incentive for some factors to leave for a competitive environment.

Since traditional offer curves are not defined in the presence of imperfect competition, they are not helpful in showing that the factor movements described above lead to an increase in the volume of trade. Basically, the problem can be circumvented by a reaction curve analysis as in Markusen (1981). To summarize briefly here, recall the assumption that p^* and η_x depend only on the world output ratio $(Y^h + Y^f)/(X^h + X^f)$. In this single monopolist case, this in turn implies that $(MRT)^f$ is monotonically related to the world output and price ratios. Thus as noted in the previous section on production taxes, it still follows from a modified version of Figures 3 and 4 (p^* cutting F's transformation curve) that country f as well as country h will have a larger trade offer associated with any given world output ratio following the factor movement. Subject again to excess demands being elastic, the result will be a larger volume of trade following the factor movement.

Now assume that X is monopolized in both countries and that each duopolist views his rival's output as fixed (the Cournot-Nash assumption). Duopolists may not price discriminate between domestic and foreign consumers. Denoting the perceived elasticity of demand of the duopolist in country i as η_x^i , the equilibrium condition for h is given by Markusen:

$$(7) \quad p^*(1 - 1/\eta_x^h) = p^*(1 - \sigma^h/\eta_x) = (MRT)^h, \quad \sigma^h = X^h/(X^h + X^f)$$

$$1/\eta_x^h = \frac{X^h}{p^*} \frac{dp^*}{dX} = \frac{X^h}{X^h + X^f} \frac{X^h + X^f}{p^*} \frac{dp^*}{dX} = \sigma^h/\eta_x$$

$1/\eta_x^h$ is thus equal to h's market share times the true market demand elasticity. Similar comments apply to country f. If both countries were identical, then the equilibrium in (7) would be symmetric and would involve both countries producing equal outputs at equal factor prices.

Suppose instead that countries differ in size as in Figure 6, where $\bar{Y}^f\bar{X}^f$ and $\bar{Y}^h\bar{X}^h$ are the production frontiers of f and h respectively. Given Heckscher-Ohlin technology and constant returns to scale, $\bar{Y}^f\bar{X}^f$ is simply a "radial blow-up" of $\bar{Y}^h\bar{X}^h$ (Markusen (1981)); that is, the MRT (and therefore factor prices) along a ray from the origin is the same on the two production frontiers. In this case, the equilibrium in (7) will involve a larger market share for f but also a higher ratio of (Y/X) produced in f relative to h as shown in Figure 6. If h and f produced the same ratio, their MRT would be equal, but the perceived marginal revenue of f would be lower due to its larger market share ($\sigma^f > \sigma^h$). The only solution to (8) involves $\sigma^f > \sigma^h$ and $(MRT)^f < (MRT)^h$. Country f will produce somewhat more X, but proportionately less Y.

Given our demand assumptions and equal consumer prices across countries, it must follow that h exports X and f exports Y at the Cournot-Nash equilibrium (Figure 6). Heckscher-Ohlin assumptions again imply a higher real wage rate in h and a higher real rental rate in f. Factor mobility will result in an inflow of the factor used intensively in the production of each country's export good.

It again follows that each country will now increase its trade offer at any given world output ratio. Figures 3 and 4 now overstate the change however due to changes in market shares. The process shown for country h in Figures 3 and 4 would result in an increased market share and thus an increase in the desired "wedge" between p^* and $(MRT)^h$ (equation 7). Beginning at H, country h would move to a point somewhere uphill of H* in Figure 3 or 4. Trade expansion is guaranteed however by the fact that the

new equilibrium in Figures 3 and 4 must not lie on $\bar{Y}'\bar{X}'$ above a ray from the origin through H. If H^* was on this ray for both countries, then each country would be retaining its market share in X, implying that $p^*(1-\sigma^h/\eta_x) > (MRT)^h$ and vice versa for country f. At any given world output ratio, factor mobility must cause σ^h to rise and σ^f to fall.

The one difference here from the previous case is that the process will stop short of specialization. The reaction curve analysis of Markusen will show that the two reaction curves eventually cross at $X^h = X^f$ or $\sigma^h = \sigma^f$ as factors begin to move. Since equation (7) holds by virtue of the fact that both countries are on their reaction curves, $\sigma^h = \sigma^f$ in turn implies $(MRT)^h = (MRT)^f$. Factor prices and market shares will be equalized at a diversified solution in which each duopolist exercises the same degree of market power (e.g., price minus marginal cost is the same in h and f). In the duopoly case, factor mobility thus drives out differential market power, but not market power per se.

V. EXTERNAL ECONOMIES OF SCALE

External or agglomeration economies of scale as a basis for trade have been examined by Jones (1968), Melvin (1969), Herberg and Kemp (1969), and Markusen and Melvin (1981). This literature assumes that firms are competitive and individually produce with constant returns to scale technology. Industry production functions are however characterized by increasing returns. Suppose we again use the two-good, two-factor Heckscher-Ohlin production model with perfect competition and constant returns in the Y sector. The production function of the i^{th} firm in the X industry is given as follows:

$$(8) \quad X_i = (X^T)^T F(L_{ix}, K_{ix}), \quad X = \sum_i X_i, \quad 0 < T < 1,$$

where the subscript i denotes the private inputs of firm i. F is assumed to be characterized by constant returns. (X^T) is the industry-wide external economy which is viewed as parametric by firm i. Firms thus behave as

price-takers and produce with constant returns in their private inputs. Private marginal products can be shown to equal social average products and thus all output is exhausted in factor payments.

Herberg and Kemp (1969), Kemp (1969) and Markusen and Melvin (1981) have established the following properties of this type of production model. First the production frontier must be convex in neighbourhood of $X = 0$ (Figures 7 and 8). If production frontiers are everywhere convex, specialization is the likely outcome (Figure 7)³. Second, at an interior competitive equilibrium, the price ratio will not equal the MRT due to the non-internalized production externality. The equilibrium relationship between the two will be $P^*(1-T) = (MRT)$ (Markusen and Melvin (1981)). The price ratio thus cuts the production frontier as shown in Figure 8. As in the production tax case, the wedge between p^* and the MRT is constant, implying that equal commodity prices imply equal MRT.

Third, if countries differ in size but have identical relative factor endowments, the MRT along a given ray from the origin will be smaller in the large country. In Figure 8, country h is assumed to be the larger country, and thus at free trade prices, h produces absolutely more X ($X^h > X^f$) and relatively more X ($X^h/Y^h > X^f/Y^f$). It then follows that h exports X and f exports Y at a free-trade equilibrium as shown in Figure 8.

Fourth, at equal commodity prices and MRT, the real price of the factor used intensively in the production of X will be higher in the country producing more X. Let the smaller and larger factor boxes in Figure 2 refer to countries f and h respectively, reflecting the assumption of equal relative factor endowments. Assume that F^* in Figure 2 is the competitive equilibrium factor allocation corresponding to point F in Figure 8. If this is true, then point A in Figure 2 cannot be the allocation for country h. Small movements up the respective contract curves from F^* and A generate the same dY , but a larger dX at A due to the returns to scale

FIGURE 7

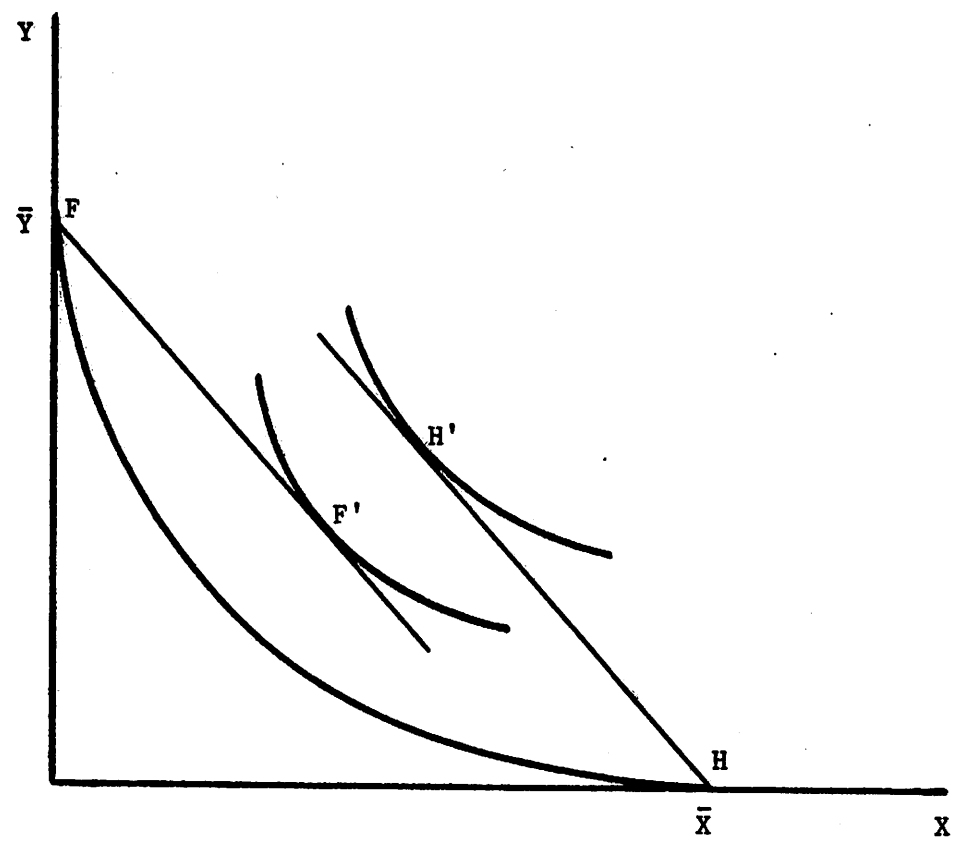
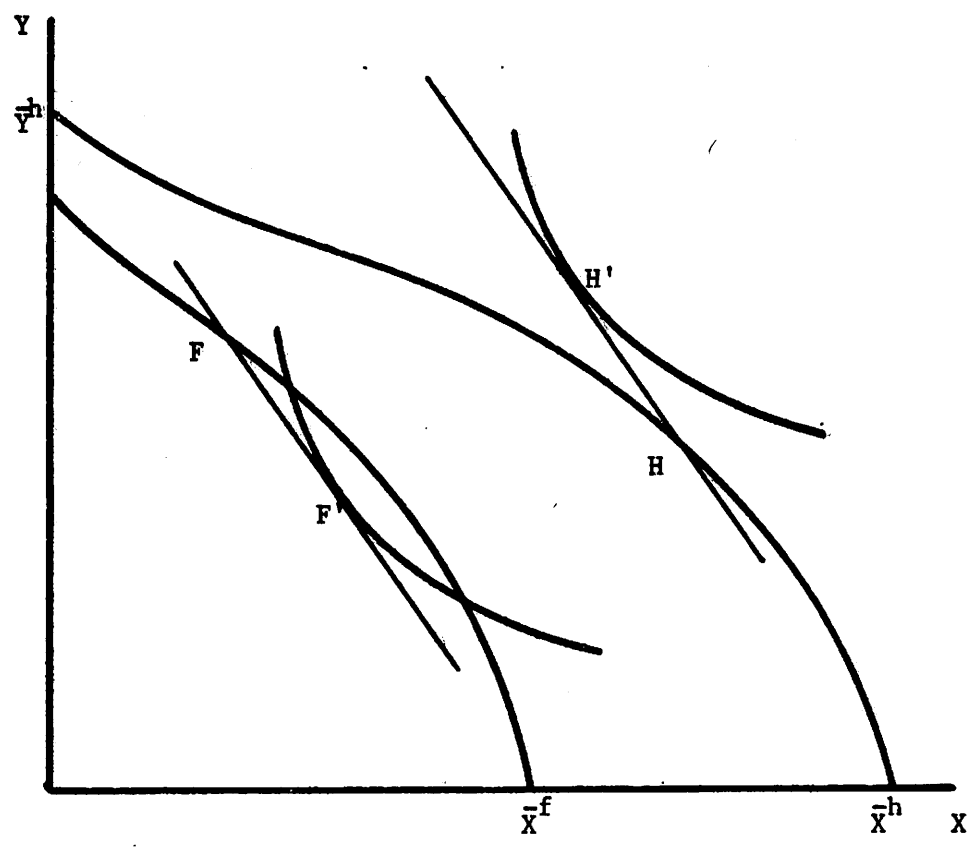


FIGURE 8



in X. Thus the MRT at F^* is greater than the MRT at A. The allocation for h corresponding to H in Figure 8 must be at a point like H in Figure 2.

Markusen and Melvin (1981) demonstrate that F and H in Figure 2 are related by $w^h > w^f$, $r^h < r^f$. Each country has the higher real price for the factor used intensively in the production of its export good. If both countries are specialized (Figure 7), each country will have a factor price ratio equal to the ratio of marginal products of the good produced evaluated at the factor endowment ratio. With equal relative or identical (Figure 7) factor endowments, w will be higher in the country specializing in the labour intensive good and vice versa for capital (the direction of trade is arbitrary). Thus in Figure 7, $w^h > w^f$ and $r^h < r^f$.⁴

Finally, the Rybczynski effect not only holds in this model, but is actually strengthened provided that the production frontier is locally concave (the production set is convex) over the relevant region (Figure 8). At a given output ratio, adding labour to country h not only lowers the MRT for the usual Rybczynski reason, but also because of the added scale economies captured in X. Removing capital from h similarly raises the MRT at a given output ratio not only because of the Rybczynski effect but also because of the loss of scale economies in X.

These findings are sufficient for our complimentary properties. The factor intensive in the production of the export good will flow into each country. If countries are already specialized (Figure 7), they will expand production and trade will increase. Factor price equalization will be achieved as diminishing marginal productivity sets in. If countries are initially diversified and differ in size (Figure 8), factor prices cannot equalize until one or both countries are specialized (Markusen and Melvin (1981)). As factors move, the Rybczynski effect acts to increase trade offers and thus leads to an increase in the volume of trade subject to the usual restrictions.

VI. SECTOR-SPECIFIC FACTORS

The sector-specific-factors models of Jones (1971), Mayer (1974), Mussa (1974), and Neary (1978) are closely related to the Heckscher-Ohlin model of production in that they all have a factor-proportions basis for trade. Like the Heckscher-Ohlin model, specific-factors models have the property that barriers to trade will generate trade-reducing factor movements if all factors are perfectly mobile.

What I wish to briefly point out here is an asymmetry between the Heckscher-Ohlin model and specific-factors models when only one factor is mobile. In the Heckscher-Ohlin model, the Mundell result continues to hold if only one factor is mobile. Tariffs imply a low price for the factor used intensively in the production of each country's export good. Since this factor is also the country's relatively abundant factor, the movement of either factor leads to a convergence in the two countries' endowment ratios and thus to a decrease in the volume of trade.

Consider now a simple specific-factors production model:

$$(9) \quad X^1 = F(L_x^1, \bar{K}_x^1), \quad Y^1 = F(L_y^1, \bar{K}_y^1), \quad \bar{L}^1 = L_x^1 + L_y^1$$

$$\bar{L}^h > \bar{L}^f, \quad \bar{K}_1^h = \bar{K}_1^f \text{ by assumption.}$$

Bars indicate fixed quantities. The two countries thus have identical endowments of sector-specific capital (\bar{K}_x^1 and \bar{K}_y^1) in the X and Y sectors. Country h has an absolutely larger amount of labour. The MRT for each country is given as follows:

$$(10) \quad (\text{MRT})^1 = - \frac{dY^1}{dX^1} = \frac{G_L^1}{F_L^1} = p^*$$

Assuming no barriers to trade, $p^* = (\text{MRT})^1$ in a competitive equilibrium.

Unlike our previous models, we now have a factor-proportions basis for trade, although the direction of trade cannot be determined without additional information about the properties of F and G. Country h will export the labour-intensive good, but the definition of factor intensity

is now a bit tricky (Jones (1971)). Let us simply assume here that the properties of F and G are such that h exports X and f exports Y.

With endowments of sector-specific capital identical between countries, (10) must imply a higher marginal product of both \bar{K}_x and \bar{K}_y in country h. For (10) to hold, the labour allocation to both X and Y must be larger in country h, thus implying higher marginal products for \bar{K}_y^h and \bar{K}_x^h relative to the corresponding marginal products in f.

Now suppose that we allow K_x to be mobile between X sectors internationally, a plausible type of foreign investment analyzed by Caves (1971). A modified version of the Rybczynski effect will occur in each country leading h to increase its production of X and decrease its production of Y at constant prices. The only aspect of the Rybczynski effect which does not continue to hold is that the expansion of X^h production will not be more than proportional to an inflow of \bar{K}_x (\bar{K}_y held constant) (Jones (1971)). Similar comments apply to f. It should be clear from Figures 3 and 4 however that this modified Rybczynski effect is still sufficient for the desired effect. At any world price ratio, trade offers expand leading to an expansion in the volume of trade if offer curves are elastic.

The process may result in factor price equalization short of specialization since the marginal product of K_x rises in f and falls in h as K_x continues to move. Such changes in relative marginal products do not of course occur in the Heckscher-Ohlin model when countries are diversified and prices are equalized by trade. In the Heckscher-Ohlin model, factor prices depend only on commodity prices whereas in the specific-factors model, factor prices depend on factor endowments as well (Jones (1971)).

VII. FACTOR TAXES

Earlier sections have considered product market distortions such as production taxes, imperfect competition, and external economies of scale. Factor market distortions can by analogy serve as bases for trade. The

analysis is generally much more complicated in the case of factor markets due to distortion-induced shifts in the production frontier (Magee (1971), (1973), Herberg and Kemp (1971)).

By using the sector-specific factors model of the previous section, however, we can avoid the complication of distortions in the production frontier. With only one factor mobile between sectors, the question of inefficient input combinations does not arise. Let (9) continue to characterize our two economies except that the endowments of all factors are now the same in the two countries. Also assume that country f places a tax, T , on the use of labour in the X sector. First-order conditions for profit maximization give us the following value of marginal product conditions.

$$(11) \quad w^f(1+T) = p^* F_\ell^f, \quad w^f = G_\ell^f$$

$$w^h = p^* F_\ell^h, \quad w^h = G_\ell^h$$

Dividing, we have the relation between $(MRT)^h$ and $(MRT)^f$.

$$(12) \quad p^* = (1+T) \frac{G_\ell^f}{F_\ell^f} = \frac{G_\ell^h}{F_\ell^h} \frac{G_\ell^i}{F_\ell^i} = (MRT)^i$$

Equation (12) thus implies that $(MRT)^f < (MRT)^h$. The production tax equilibrium shown in Figure 5 also serves to represent the present problem. p^* is tangent to the production surface for h (point H) but cuts the surface for f (point F). Equation (12) requires that country f produce more Y and less X relative to country h. Country f thus exports Y and country h exports X as shown in Figure 5.

Equation (11) in turn implies that $w^f < w^h$ and diminishing marginal products imply that $r_x^h > r_x^f$ and $r_y^h < r_y^f$ where r_i denotes the rental rate on K_i . If either type of sector-specific capital is allowed to move internationally, one or both countries will receive the type of capital used intensively in the production of its export good and lose the other type of

capital. As in the previous section, capital prices can equalize without specialization due to the fact that factor prices depend on endowments as well as on commodity prices. Invoking the modified Rybczynski effect (Jones (1971)), trade offers and the volume of trade increase with the factor movements.

VIII. MONOPSONY

Just as the one country monopoly case was very similar to the production tax case, so too is a simple monopsony problem similar to the factor tax case. Using the same sector-specific-factors model employed in the previous two sections, suppose that a producer of X in country f has monopsony power in the purchase of labour, but has no monopoly power in output markets. First-order value of marginal product conditions follow from Feenstra (1980), McCulloch and Yellen (1980), and Markusen and Robson (1980).

$$(13) \quad w^f (1 + 1/\epsilon_\ell) = p^* F_\ell^f, \quad w^f = G_\ell^f$$

$$w^h = p^* F_\ell^h, \quad w^h = G_\ell^h,$$

where ϵ_ℓ is the elasticity of labour supply to the X industry with respect to w . ϵ is positive by virtue of the fact that hiring more labour away from the Y industry drives up the marginal product of L in Y, and thus drives up w . Dividing, we have

$$(14) \quad p^* = (1 + 1/\epsilon_\ell) \frac{G_\ell^f}{F_\ell^f} = \frac{G_\ell^h}{F_\ell^h}, \quad (MRT)^f < (MRT)^h$$

Once again, Figure 2 adequately represents the equilibrium and the comments of the previous section about the direction of trade and factor price differences continue to hold. Mobility of either type of capital will lead to an inflow (outflow) of the type of capital used intensively in the production of each country's export (import) good. Perfect capital mobility need not imply specialization for the reasons noted above. As in

the previous two cases, the modified Rybczynski effect leads to an expansion in trade offers and, subject to our offer curve restrictions, leads to an increase in the volume of trade.

IX. SUMMARY AND CONCLUSIONS

The purpose of this paper was to present a number of models in which factor movements generated by international factor price differences lead to an increase in the volume of world trade. With the exception of the specific-factors model presented in Section VI, these models share the characteristic that the basis for trade is something other than differences in factor proportions between countries. As noted in the Introduction, these models taken together suggest a fairly important idea: the notion that trade in goods and factors are substitutes may be a rather special result which is generally true only for the Heckscher-Ohlin basis for trade.

The specific factors case of Section VI may seem to be a bit different from the other cases, and admittedly I could only force the complementarily result by restricting the number of mobile factors. Yet the specific-factors model shares with several of the other models the non-Heckscher-Ohlin property that factor prices are not solely determined by the MRT when a country is diversified. In this sense, the specific-factors model is useful in helping to pin down the key characteristics of the complementarily phenomenon.

If there is a key here, I think that it might lie in the fact that the distribution of factors necessary for a world Pareto-optimal allocation is inherently arbitrary in the Heckscher-Ohlin model if commodity prices are equalized by trade. It simply doesn't matter where we locate factors provided that endowments lie in the cone of diversification. In all of the models presented here, the distribution of factors matters very much. More specifically, Pareto-optimal allocations require relative factor endowments to be different among countries except in the specific factors model in which

case they must be the same⁵. Pareto-optimal allocations require a country to have more of the factor used intensively in the production of any good for which that country possesses a special advantage (i.e., the export good). This was the case in the models based on differences in production technology and on returns to scale. Similarly, optimality requires a country to have less of the factor used intensively in the production of any good for which the country possesses a special disadvantage. This was the case in the production tax, monopoly, factor tax, and monopsony models.

Thus beginning with equal relative endowments, factors move to make endowments unequal and make each country relatively abundant (scarce) in factors used intensively in the production of domestically advantaged (disadvantaged) goods. In a sense, factor mobility creates a factor proportions basis to reinforce the other basis for trade. In all of the models presented here, factor mobility leaves countries relatively well endowed with the factor used intensively in the production of the export good. In the Heckscher-Ohlin model, this is of course the cause of trade in goods whereas in the present models it is the result of trade in factors.

FOOTNOTES

1. With respect to the decrease in \bar{K}^h shown in Figure 4, trade will only increase up to the point that h specializes in X after which the trade offer will decrease. Thus if factors continue to move after one or both countries are specialized, the trade offer of one country could contract.
2. This same property is used by Brecher and Alejandro (1977) in analyzing a tariff-induced capital flow for a small open economy.
3. The production frontier can have more than one inflection point. Since we cannot get into a taxonomy of possibilities here, we will restrict ourselves to the two cases shown in Figures 7 and 8. Markusen and Melvin (1981) in fact show that these are the only two possibilities if both production functions are Cobb-Douglas.
4. Actually, this is not quite right. If returns to scale are strong and the differences factor intensities small, the real price of both factors may be higher in the country specializing in the increasing returns good when one or both countries are specialized. We will assume that this is not the case here.
5. In the presence of taxes and other distortion, we should probably refer to "constrained" Pareto-optimal allocations.

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